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AN ESTIMATE OF KAMISHAK BAY HERRING FECUNDITY

by

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TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	iv
LIST OF FIGURES	iv
LIST OF APPENDICES	iv
ABSTRACT	1
INTRODUCTION	2
METHODS	3
RESULTS	4
DISCUSSION	4
LITERATURE CITED	5
TABLES	8
FIGURES	11
APPENDIX	16

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Fecundity sample size by length category	8
2. Kamishak Bay herring mean weight, fecundity and GSI at age	9
3. Mean weight, fecundity, and gonosomatic index at age for other herring stocks in Alaska	10

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Kamishak Bay, Lower Cook Inlet Management Area	11
2. Relationship of Kamishak Bay herring fecundity and weight	12
3. Relationship of Kamishak Bay herring fecundity and length	13
4. Relationship of Kamishak Bay herring GSI and weight	14
5. Relationship between herring fecundity and weight for Kamishak Bay, PWS, and three British Columbia stocks	15

LIST OF APPENDICES

<u>Appendix</u>	<u>Page</u>
A. Lower Cook Inlet herring fecundity data from Kamishak Bay	16

ABSTRACT

The number of eggs per female of Pacific herring *Clupea pallasii* was estimated from a sample of 155 Kamishak Bay herring from Lower Cook Inlet. Average fecundity ranged from 11,830 eggs per female at age 3 to 53,620 eggs per female at age 11. The gonosomatic index (GSI) ranged from 17.3% at age 3 to 25.0% at age 12. Eggs per female were regressed on length and body weight. The log weight-log fecundity regression provided the best coefficient of determination ($r^2 = 0.82$, d.f. = 153).

KEY WORDS: fecundity, herring, Lower Cook Inlet, Kamishak Bay

INTRODUCTION

Pacific herring *Clupea pallasii* migrate into and spawn in Kamishak Bay of the Kamishak District, Lower Cook Inlet management area (Figure 1) from mid-April to early May. These herring are managed as a discrete population and have sustained a spring sac roe fishery by purse seine gear since 1985. The fishery was closed from 1980-1984 after providing harvests since 1973 (Schroeder 1989). The Alaska Department of Fish and Game (ADF&G) has maintained a resource monitoring program to collect data from the fishery and the contributing spawning population. Sampling of the herring catch for age, sex, weight and length data began in 1974. Assessment of the spawning biomass began in 1978 with a program of aerial surveys and test fishing for age composition. An intertidal survey of herring egg deposition was conducted in 1991 (Yuen 1993).

In 1990 and 1991 herring samples were collected to estimate the fecundity of this population. This information is needed to estimate spawning biomass from the number of eggs deposited by back-calculation based on sex composition and size/age specific estimates of fecundity (Haegele et al. 1981; Schweigert et al. 1985; Yuen 1993). Fecundity estimates are also important in describing differences in biological productivity among herring stocks which determine allowable harvest and roe recovery potential. The seafood industry has provided an economic incentive to maximize roe recovery in Alaska's spring herring fisheries by adjusting the price per ton by a fixed value for every percentage point above or below 10% roe recovery (Brannian and Rowell 1991). While the size of herring increases with latitude to a maximum in the Togiak stock and decreases northward (Rowell 1986; Fried et al. 1982a, 1982b, 1983, 1984, Lebida and Sandone 1988), size-specific fecundity is thought to be inversely related to latitude (Paulson and Smith 1977). Hay (1985) found that the gonosomatic index (GSI, the female gonad size expressed as a percentage of total body weight) increases with size of female. This conclusion supports the observation that an increase in fecundity with size and age exceeds growth (Hempel 1979). This trend is also apparent in Atlantic herring (*C. harengus*) stocks where the exponent (b) in the allometric relationship of fecundity with fish length ($F=aL^b$) ranged from 3.4 to 6.8 (Schopka 1971).

Although these studies suggest that roe recovery potentials are stock specific, environmental conditions and food supply can affect growth and change both absolute and relative fecundity (Nikolsky et al. 1973). Understanding a stock's reproductive parameters, such as fecundity, can be useful in establishing herring management policies. The objective of our project was to estimate the fecundity of the female herring spawning in Kamishak Bay by size and age. We hoped that collecting such information would add to our general understanding of herring productivity.

METHODS

Herring sampled for fecundity were obtained during annual age-weight-length-and sex (AWLS) commercial catch sampling in 1990 and 1991. Herring were randomly collected from each commercial fishery opening and from test fishing harvests to estimate roe recovery potential. Samples were packed in 15-kg boxes and flown to Homer for initial processing (Yuen et al. 1991, 1994). Our sampling goal was 160 females: 20 from each of eight 10 mm length categories (< 200, 201-210, 211-220, ..., and > 260 mm). Herring that appeared to have lost eggs during transportation from the field to the laboratory or during the sampling process were not included in analyses. Each herring was measured to the nearest millimeter from the tip of snout to the end of the hyperal plate and weighed to the nearest gram. Sex was determined from an inspection of either the gonads or sex products. Ovaries from ripe females, those with translucent eggs, were removed, weighed, and frozen for later processing. Ovaries were placed in plastic bags which were labeled with location, date, and AWLS number. One scale was removed from each herring, cleaned, dipped in a 10% mucilage solution and positioned unsculptured side down on a labeled glass slide. Images of scales were viewed at a magnification of 29X with a microfiche reader, and the number of annuli per scale was counted to determine age. Data for each herring were recorded on preprinted forms along with a unique AWLS number.

Processing of ovaries occurred in Cordova following procedures developed for Prince William Sound spawn deposition surveys (E. Brown, ADF&G, Cordova, personal communication). Ovaries were thawed and weighed to the nearest 0.01 g. Four 0.1 to 0.3 g (approximately 200 eggs) subsamples were randomly taken from each roe sample, placed in labeled petri dishes, and weighed. Gilson's fluid was then poured into the petri dishes and the subsample allowed to soak for a minimum of 5 minutes to loosen the eggs from the connective membrane. Once eggs were loose, the Gilson's fluid was decanted and the number of eggs in each subsample were counted.

For each herring, a mean and standard deviation of the number of eggs per gram was calculated from the four subsamples. The fecundity of each female was estimated by multiplying the mean number of eggs per gram in subsamples by the total weight of the ovaries. Standard deviation of the total egg count or fecundity was total sample weight multiplied by the standard deviation of the four subsamples.

Gonad weight was defined as the weight of the ovaries removed from each female. The GSI was the percentage of total body weight represented by the gonads and was calculated by dividing gonad weight by body weight for each female sampled.

The relationship between egg count and body size was estimated with linear, log-linear and log-log regressions of egg count on herring length and weight. The regression with the largest coefficient of determination (r^2) was selected as the best predictor of herring fecundity. In choosing the best model, we also considered the general fit of the line through the data and the pattern of residuals.

RESULTS

We were able to obtain data from 155 herring between 161 and 290 mm in length (Appendix A). Most individuals were concentrated between 201 and 270 mm. Sample sizes in the length categories between 201 and 270 mm ranged from 14 to 27 (Table 1). Ages for only 86 of the 155 female herring sampled could be determined from scales. Mean fecundity for herring aged 3 through 13 (unweighted) was 37,225 eggs per female ranging from 11,830 at age 3 to 53,620 at age 11. Mean fecundity decreased to 52,827 eggs per female at age 12 and to 49,699 eggs per female at age 13 (Table 2). The overall mean GSI for female herring aged 3 through 13 was 22.6%. The slope of the regression of GSI on weight was not significantly different from zero at $\alpha = 0.05$ (p-value >0.1) (Figure 2). Mean weight of herring ranged from 82 g at age 3 to 340 g at age 12.

The log-log regression of eggs per female on weight explained about 82% of the variation (r^2) between fecundity and weight (Figure 3):

$$E = e^{4.79 + 1.04 \ln(W)}, \quad (1)$$

where E = eggs per females, W = herring weight, and \ln = natural logarithm. Standard Error (SE) of the fecundity estimate was 0.214.

Alternately, a log-linear regression of fecundity on length explained only about 75% of the observed variation in fecundity (Figure 4):

$$E = e^{6.73 + 0.015L}, \quad (2)$$

where L = mean length. SE of this fecundity estimate was 0.254.

DISCUSSION

The geographically closest spawning population of herring, for which similar data were available, occurs in Prince William Sound (PWS). A study conducted by Baker et al. (1993) on PWS herring also found that fecundity, egg weight and gonad weight were linearly related to female body weight. Mean weight, fecundity, and GSI at age of Kamishak Bay herring during 1990-1991 were consistently greater than those of PWS herring during 1980-1993 (Table 3). In the Bering Sea, Togiak herring are heavier and more fecund at age than those from Kamishak Bay and PWS (Brannian and Rowell 1991; Table 3). In contrast, the maximum average GSI in Kamishak Bay was 25% at age 12 compared to 23% at age 9 for Togiak herring.

Herring from three British Columbia stocks; Queen Charlotte Island, Strait of Georgia and West Coast of Vancouver Island, are also heavier and more fecund at age than herring from either Kamishak Bay or PWS (Hourston et al. 1981). Togiak Bay herring, however, are heavier and more fecund at age than British Columbia herring.

Herring fecundity-weight relationships for Alaska and British Columbia stocks appear to be inversely related to latitude (Figure 5). However, fecundity weight estimates between the local stocks of British Columbia do not exhibit this trend. This supports the general findings of Paulson and Smith (1977). The higher fecundities found in the more northern Togiak Bay may be more accurately attributed to the greater productivity of the Bering Sea than the Gulf of Alaska.

Unlike Hay (1985) Kamishak Bay herring did not display a statistically significant increase in GSI with weight of female. We do note however, that the smallest values of GSI were observed for the youngest female herring. We also found the exponent in the allometric relationship of fecundity with fish length to be on the lower boundary (3.4) of the range found by Schopka (1971).

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Table 1. Fecundity sample size by length category.

Length Category	Frequency
161 - 170	2
171 - 180	6
181 - 190	8
191 - 200	4
201 - 210	14
211 - 220	15
221 - 230	16
231 - 240	15
241 - 250	19
251 - 260	20
261 - 270	27
271 - 280	6
281 - 290	3
Total	155

Table 2. Kamishak Bay herring mean weight, fecundity, and GSI at age.

Age ^a	n	Mean Weight (g)	SD	Mean Fecundity	SD	Mean GSI ^b %	SD
3	9	82	4.9	11,830	3,619	17.3	4.8
4	13	123	16.2	18,968	3,978	19.3	2.2
5	13	171	25.3	25,417	5,722	21.4	3.3
6	4	192	39.7	29,090	10,722	22.2	3.0
7	6	230	42.0	37,801	9,807	24.6	3.9
8	13	273	14.6	39,413	7,692	23.2	2.2
9	4	280	23.2	43,759	14,971	24.1	5.4
10	9	283	25.0	47,051	3,849	24.4	2.1
11	7	310	32.6	53,620	16,515	24.8	3.9
12	4	340	27.3	52,827	15,602	25.0	2.6
13	4	324	72.9	49,699	16,611	22.7	3.8
Aged ^c	86	218	86.2	33,988	16,126	22.1	4.0
Total	155	206	78.9	31,319	14,329	22.7	4.2
Mean		237	85.1	37,225	14,128	22.6	2.5

^a Ages available for 86 of 155 herring sampled.

^b GSI = gonosomatic index; the female gonad size expressed as a percentage of total body weight.

^c Average across ages giving equal weight to each age.

Table 3. Mean weight, fecundity and gonosomatic index at age for herring stocks in Alaska.

Age	Mean Weight (g)			Mean Fecundity			Mean GSI (%)		
	PWS ^a	Togiak ^b	Kamishak Bay	PWS ^a	Togiak ^c	Kamishak Bay	PWS ^c	Togiak ^c	Kamishak Bay
3	70		82	9,030		11,830		16.0	17.3
4	93	151	123	12,827	37,300	18,968	18.6	15.6	19.3
5	113	196	171	15,878	34,600	25,417	20.7	18.5	21.4
6	132	246	192	18,897	57,100	29,090	21.8	19.3	22.2
7	148	295	230	21,666	75,100	37,801	22.8	21.2	24.6
8	161	335	273	23,778	82,300	39,413	22.9	22.6	23.2
9	176	374	280	26,328	99,800	43,759	22.2	23.0	24.1
10		397	283		93,700	47,051	23.0	22.2	24.4
11			310			53,620		22.5	24.8
12			340			52,827		22.7	25.0
13			324			49,699			22.7

^a Funk (1994)

^b Rowell and Brannian (1994)

^c Brannian and Rowell (1991)

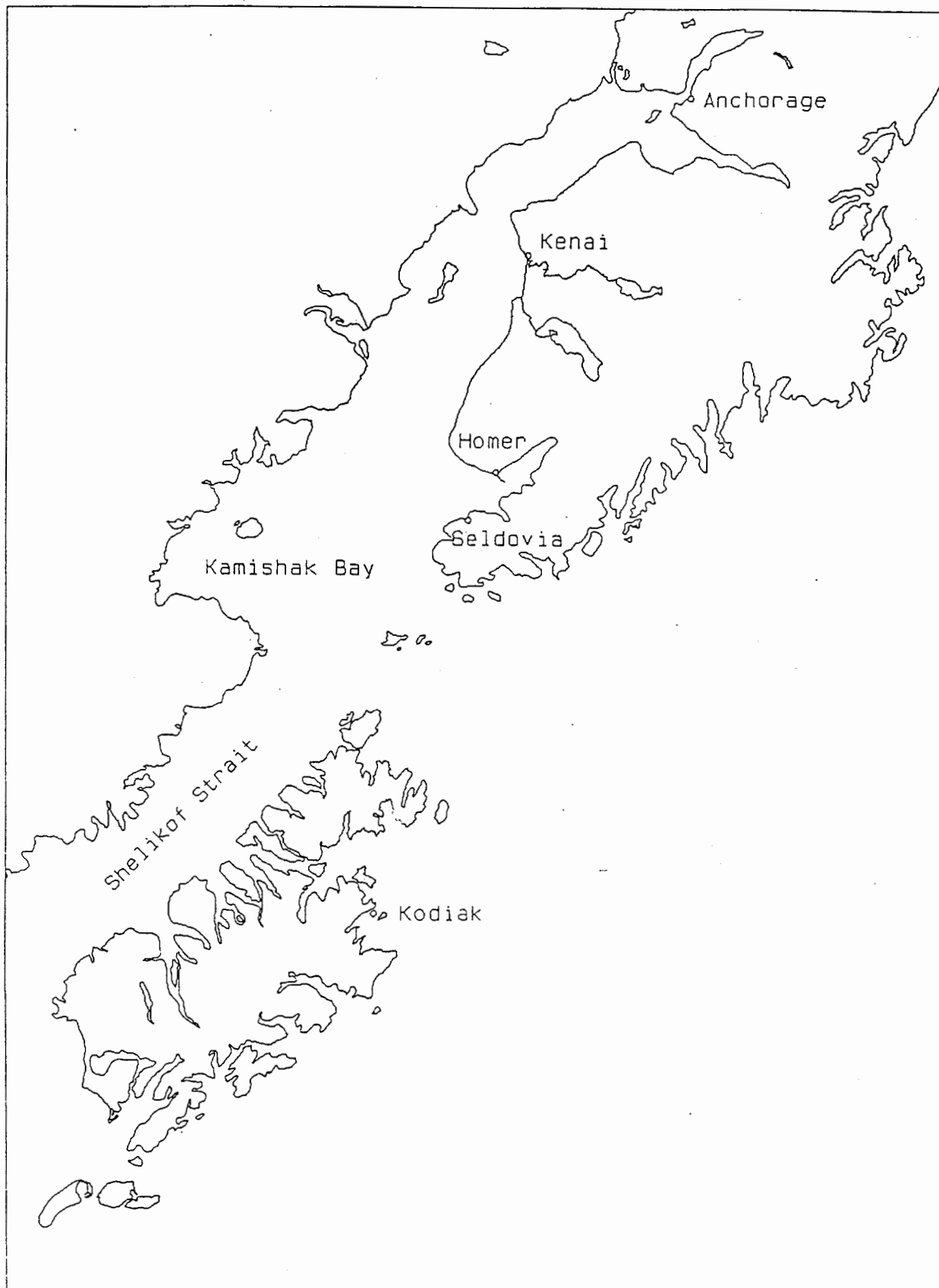
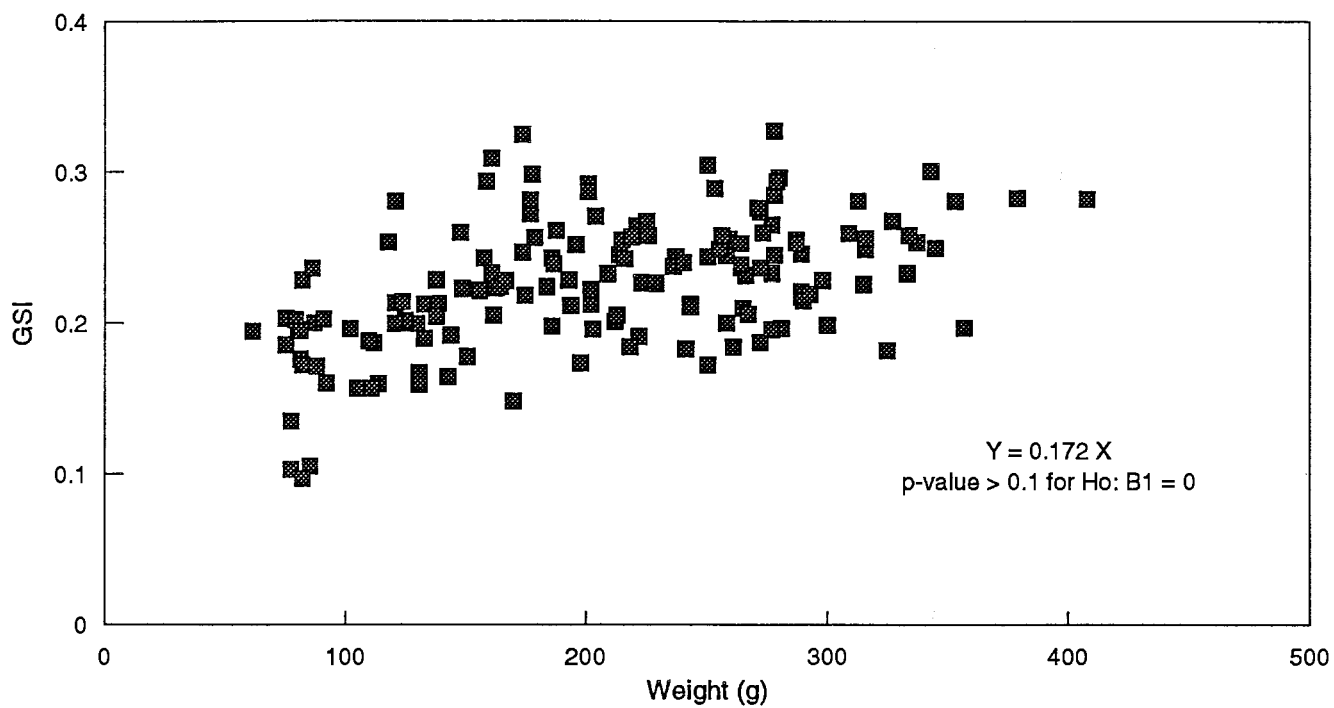


Figure 1. Kamishak Bay, Lower Cook Inlet Management Area



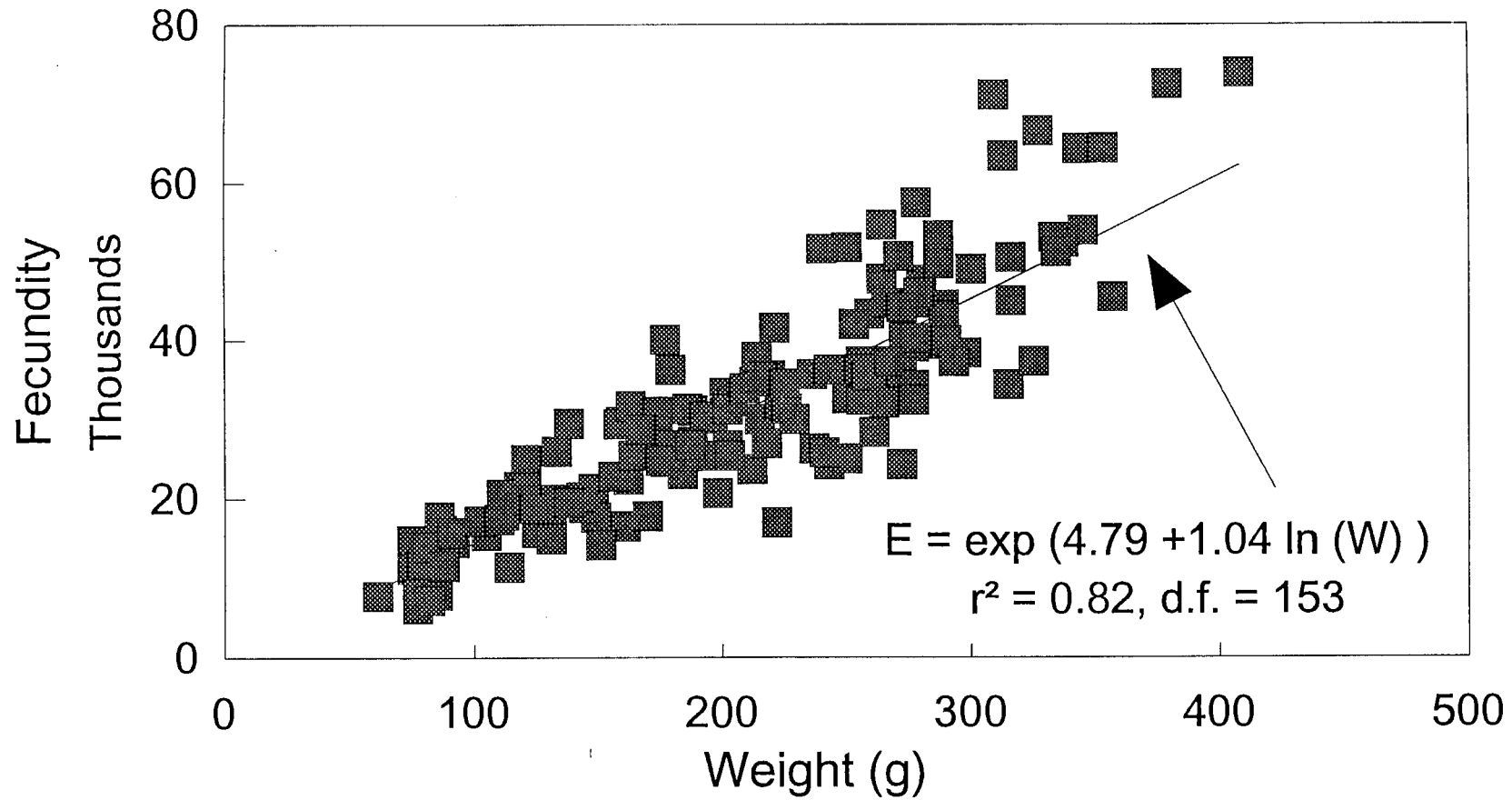


Figure 3. Relationship of Kamishak Bay herring fecundity and weight.

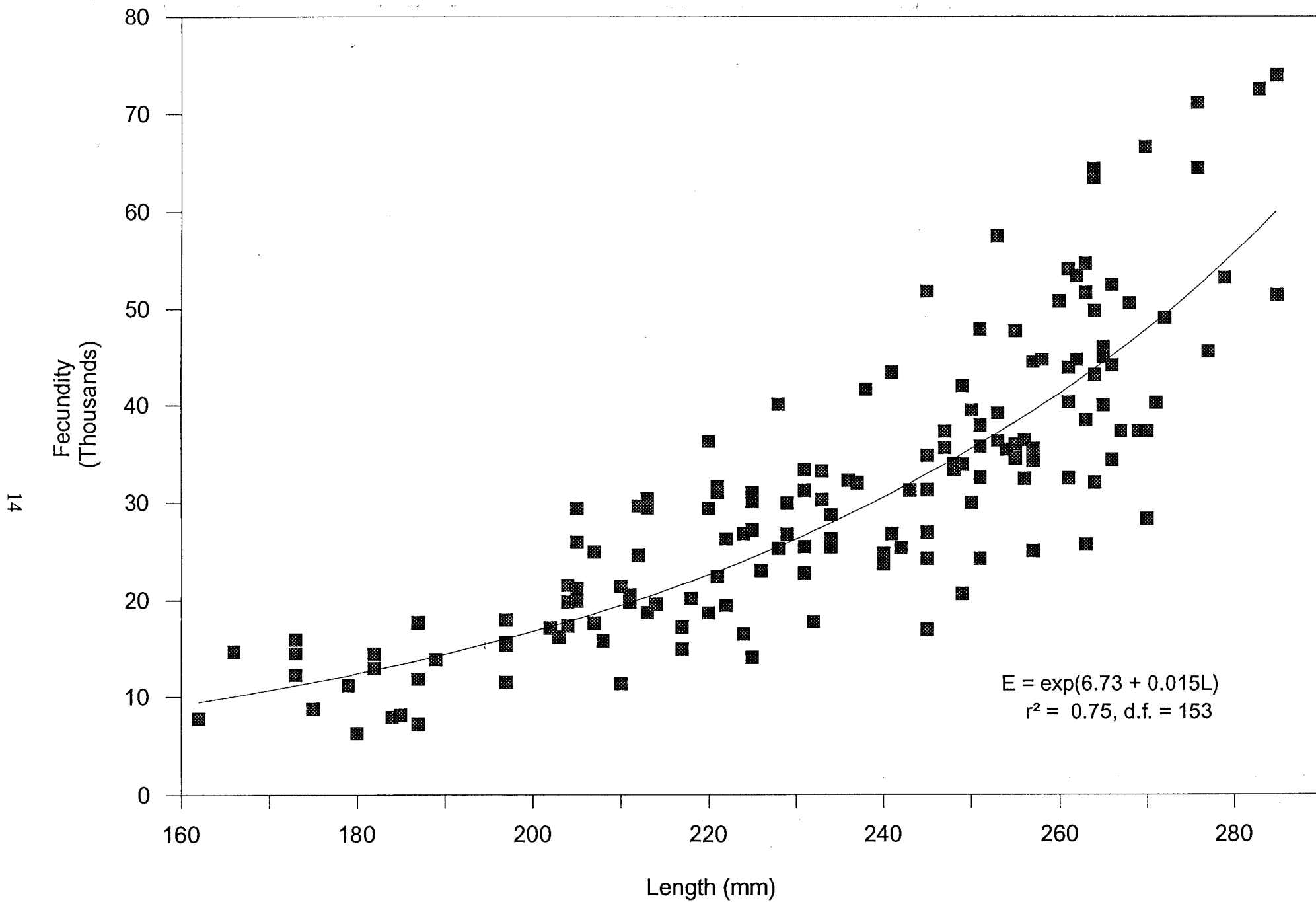


Figure 4. Relationship of Kamishak Bay herring fecundity and length.

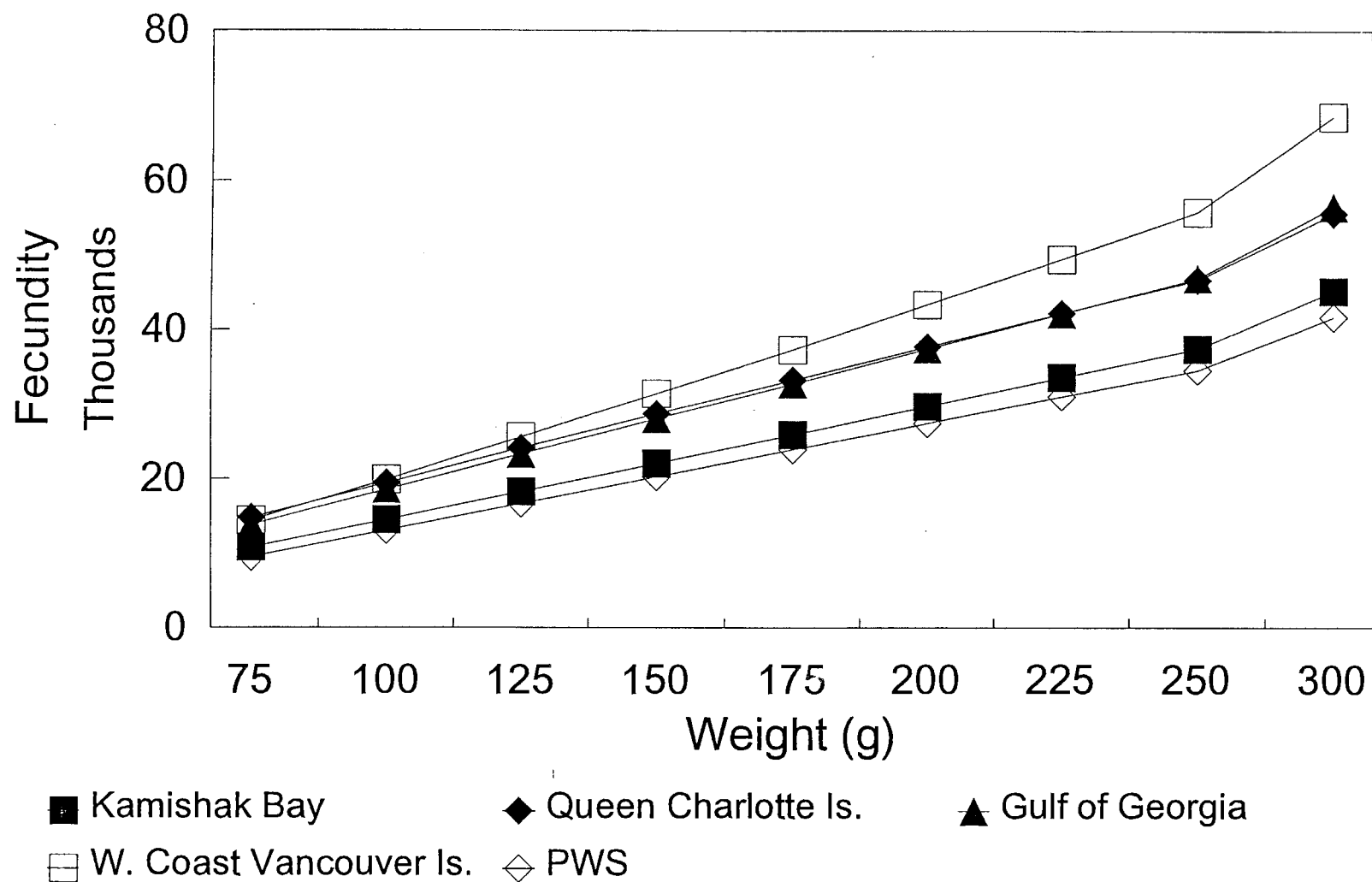


Figure 5. Relationship between herring fecundity and weight for Kamishak Bay, PWS and three British Columbia stocks.

Appendix A. Lower Cook Inlet herring fecundity data from Kamishak Bay.

Sample	AWL		Fish		Skein Weight (Thawed)	Subsamples																Mean Egg/g	SD	CV	Estimated Eggs/Female	
	Card	#	Age	Len		Wt	1		2		3		4		Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g					Wt
12	1	1		255	225	60.06	0.14	93	664.3	0.15	96	640.0	0.19	91	478.9	0.16	82	512.5	573.9	106.1	18.5%					34,470
12	1	2		253	277	73.30	0.14	70	500.0	0.11	68	618.2	0.20	93	465.0	0.23	127	552.2	533.8	77.0	14.4%					39,130
12	1	4		234	194	41.03	0.17	113	664.7	0.14	85	607.1	0.07	42	600.0	0.14	85	607.1	619.7	34.8	5.6%					25,428
12	1	5		222	178	53.09	0.10	54	540.0	0.16	80	500.0	0.17	72	423.5	0.12	62	516.7	495.0	58.2	11.8%					26,282
12	1	6		237	223	50.43	0.13	80	615.4	0.15	85	566.7	0.11	72	654.5	0.18	126	700.0	634.1	65.5	10.3%					31,980
12	1	7		225	188	49.06	0.10	61	610.0	0.16	89	556.3	0.18	100	555.6	0.17	84	494.1	554.0	54.7	9.9%					27,178
12	1	9		213	174	56.45	0.12	68	566.7	0.17	87	511.8	0.23	124	539.1	0.15	79	526.7	536.1	26.9	5.0%					30,260
12	1	10		229	202	42.93	0.13	82	630.8	0.19	122	642.1	0.22	136	618.2	0.18	108	600.0	622.8	20.8	3.3%					26,735
12	1	11		224	177	49.04	0.17	104	611.8	0.22	99	450.0	0.10	55	550.0	0.12	69	575.0	546.7	80.0	14.6%					26,810
12	1	4		221	188	49.06	0.16	101	631.3	0.15	81	540.0	0.14	91	650.0	0.18	128	711.1	633.1	81.8	12.9%					31,059
12	1	17		205	161	49.68	0.20	103	515.0	0.13	84	646.2	0.12	75	625.0	0.10	58	580.0	591.5	67.0	11.3%					29,388
12	1	18		207	149	33.15	0.13	69	530.8	0.1	54	540.0	0.14	66	471.4	0.11	64	581.8	531.0	52.5	9.9%					17,603
12	1	19		242	203	39.81	0.13	75	576.9	0.17	107	629.4	0.16	109	681.3	0.20	132	660.0	636.9	52.3	8.2%					25,355
12	1	20		224	161	37.49	0.14	66	471.4	0.17	69	405.9	0.17	71	417.6	0.19	88	463.2	439.5	37.6	8.6%					16,478
12	2	2		205	148	38.46	0.11	59	536.4	0.21	109	519.0	0.12	59	491.7	0.20	133	665.0	553.0	88.8	16.1%					21,269
12	2	7		233	201	57.58	0.21	124	590.5	0.24	125	520.8	0.16	99	618.8	0.18	104	577.8	577.0	47.5	8.2%					33,221
12	2	9		247	219	56.22	0.11	76	690.9	0.14	87	621.4	0.12	68	566.7	0.14	91	650.0	632.3	60.3	9.5%					35,545
12	2	10		249	264	62.42	0.10	48	480.0	0.23	128	556.5	0.12	71	591.7	0.12	65	541.7	542.5	53.8	9.9%					33,861
12	2	13		221	163	36.37	0.14	127	907.1	0.15	134	893.3	0.15	91	606.7	0.11	118	1072.7	870.0	223.5	25.7%					31,641
12	2	14		245	226	58.23	0.13	72	553.8	0.13	63	484.6	0.24	135	562.5	0.17	93	547.1	537.0	41.0	7.6%					31,270
12	2	15		245	222	42.38	0.14	51	364.3	0.16	70	437.5	0.11	38	345.5	0.13	59	453.8	400.3	61.7	15.4%					16,964
12	2	16		205	133	28.21	0.14	128	914.3	0.18	171	950.0	0.16	149	931.3	0.14	124	885.7	920.3	31.5	3.4%					25,962
12	2	18		261	277	54.18	0.22	111	504.5	0.10	59	590.0	0.12	71	591.7	0.12	85	708.3	598.6	96.6	16.1%					32,434
12	2	20		212	159	46.63	0.13	69	530.8	0.15	96	640.0	0.14	88	628.6	0.20	149	745.0	636.1	101.2	15.9%					29,661
12	3	3		229	215	54.72	0.18	111	616.7	0.17	89	523.5	0.18	98	544.4	0.20	101	505.0	547.4	56.5	10.3%					29,954
12	3	7		234	237	57.73	0.22	102	463.6	0.13	56	430.8	0.17	78	458.8	0.19	89	468.4	455.4	19.5	4.3%					26,291
12	3	8		257	250	43.04	0.26	150	576.9	0.21	127	604.8	0.17	105	617.6	0.15	79	526.7	581.5	46.5	8.0%					25,028
12	3	9		238	221	58.34	0.24	166	691.7	0.14	95	678.6	0.19	127	668.4	0.21	171	814.3	713.2	78.6	11.0%					41,610
12	3	13		212	177	48.18	0.14	60	428.6	0.17	80	470.6	0.13	72	553.8	0.14	83	592.9	511.5	86.8	17.0%					24,642
12	3	14		263	241	44.02	0.14	70	500.0	0.18	104	577.8	0.10	63	630.0	0.14	88	628.6	584.1	70.5	12.1%					25,712
12	3	20		228	177	49.75	0.16	126	787.5	0.19	147	773.7	0.13	115	884.6	0.22	171	777.3	805.8	61.1	7.6%					40,087
12	4	4		255	280	82.92	0.19	103	542.1	0.14	83	592.9	0.19	106	557.9	0.16	97	606.3	574.8	34.4	6.0%					47,660
12	4	11		175	82	14.10	0.17	85	500.0	0.23	154	669.6	0.15	105	700.0	0.14	87	621.4	622.7	101.6	16.3%					8,781
12	4	12		255	272	74.33	0.17	97	570.6	0.18	79	438.9	0.23	100	434.8	0.16	78	487.5	482.9	72.9	15.1%					35,897
12	5	6		256	256	65.93	0.16	79	493.8	0.10	46	460.0	0.12	66	550.0	0.21	97	461.9	491.4	48.5	9.9%					32,399
12	5	10		251	250	60.90	0.08	40	500.0	0.13	82	630.8	0.25	117	468.0	0.13	70	538.5	534.3	81.4	15.2%					32,539
12	5	18		205	133	25.23	0.14	104	742.9	0.11	97	881.8	0.14	115	821.4	0.13	92	707.7	788.4	90.4	11.5%					19,893
12	6	9		213	144	27.58	0.18	118	655.6	0.17	117	688.2	0.11	69	627.3	0.10	75	750.0	680.3	60.9	9.0%					18,762
12	6	10		213	165	37.00	0.13	99	761.5	0.16	133	831.3	0.15	136	906.7	0.18	142	788.9	822.1	73.0	8.9%					30,417
12	6	16		203	130	25.94	0.21	128	609.5	0.12	85	708.3	0.11	68	618.2	0.17	95	558.8	623.7	71.8	11.5%					16,179
12	7	1		261	345	86.05	0.23	150	652.2	0.20	122	610.0	0.20	109	545.0	0.17	120	705.9	628.3	78.5	12.5%					54,062
12	11	12		162	61	11.86	0.19	146	768.4	0.16	82	512.5	0.21	143	681.0	0.09	59	655.6	654.4	122.6	18.7%					7,761
20	1	8		207	121	33.91	0.19	124	652.6	0.12	93	775.0	0.16	129	806.3	0.17	120	705.9	734.9	79.7	10.9%					24,922
20	1	11		197	105	16.46	0.16	133	831.3	0.24	145	604.2	0.16	214	1337.5	0.15	145	966.7	934.9	354.8	37.9%					15,388
20	1	14		221	162	33.21	0.20	131	655.0	0.24	162	675.0	0.13	84	646.2	0.19	138	726.3	675.6	41.4	6.1%					22,437
20	1	17		236	204	55.13	0.12	69	575.0	0.23	143	621.7	0.14	76	542.9	0.10	60	600.0	584.9	39.2	6.7%					32,245

AWL		Fish			Skein	Subsamples																Mean	SD	CV	Estimated
Sample	Card	#	Age	Len	Wt	Weight (Thawed)	Wt	Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g	Egg/g						
17	20	1	19	204	118	29.89	0.19	117	615.8	0.16	126	787.5	0.22	156	709.1	0.21	162	771.4	721.0	89.9	12.5%	21,549			
	20	1	20	240	212	42.55	0.14	78	557.1	0.23	123	534.8	0.18	97	538.9	0.19	113	594.7	556.4	31.6	5.7%	23,674			
	20	2	1	210	114	18.22	0.21	127	604.8	0.21	137	652.4	0.19	110	578.9	0.21	140	666.7	625.7	47.2	7.5%	11,400			
	20	2	7	225	196	49.26	0.12	67	558.3	0.26	174	669.2	0.25	164	656.0	0.21	118	561.9	611.4	68.6	11.2%	30,116			
	20	2	9	220	179	45.85	0.10	76	760.0	0.10	83	830.0	0.15	105	700.0	0.24	209	870.8	790.2	87.3	11.0%	36,231			
	20	2	10	243	202	44.76	0.19	148	778.9	0.19	113	594.7	0.27	209	774.1	0.19	122	642.1	697.5	107.8	15.4%	31,219			
	20	2	13	226	184	41.20	0.12	74	616.7	0.16	93	581.3	0.18	90	500.0	0.12	65	541.7	559.9	58.1	10.4%	23,068			
	20	2	17	250	229	51.77	0.13	78	600.0	0.23	126	547.8	0.21	120	571.4	0.27	161	596.3	578.9	28.0	4.8%	29,969			
	20	3	18	249	253	73.08	0.23	137	595.7	0.19	116	610.5	0.30	189	630.0	0.21	97	461.9	574.5	88.2	15.4%	41,986			
	20	5	7	197	112	20.91	0.11	92	836.4	0.15	154	1026.7	0.13	95	730.8	0.17	142	835.3	857.3	142.4	16.6%	17,926			
	20	5	13	253	278	90.98	0.18	119	661.1	0.17	126	741.2	0.21	114	542.9	0.11	64	581.8	631.7	101.6	16.1%	57,476			
	20	7	2	241	259	66.20	0.26	170	653.8	0.32	229	715.6	0.19	125	657.9	0.17	101	594.1	655.4	57.3	8.7%	43,386			
	20	8	4	245	243	51.56										0.17	80	470.6	470.6			24,264			
	20	8	15	180	77	7.92				0.10	75	750.0	0.10	74	740.0	0.15	131	873.3	787.8	91.0	11.5%	6,239			
	20	11	8	182	82	18.69	0.16	139	868.8	0.27	211	781.5	0.22	149	677.3	0.18	139	772.2	774.9	90.4	11.7%	14,483			
	20	11	19	173	92	14.73	0.15	134	893.3	0.18	173	961.1	0.15	147	980.0	0.13	144	1107.7	985.5	103.4	10.5%	14,517			
	20	13	8	173	87	17.39	0.21	196	933.3	0.23	203	882.6	0.30	285	950.0	0.12	109	908.3	918.6	34.0	3.7%	15,974			
	20	14	2	166	75	15.23	0.18	172	955.6	0.14	132	942.9	0.22	221	1004.5	0.15	143	953.3	964.1	31.8	3.3%	14,683			
	20	14	18	173	81	14.27	0.12	99	825.0	0.13	109	838.5	0.17	144	847.1	0.11	102	927.3	859.4	53.3	6.2%	12,264			
	2	1	6	13	277	357	70.33	0.27	171	633.3	0.21	133	633.3	0.22	144	654.5	0.15	100	666.7	647.0	19.1	2.9%	45,501		
	2	1	14	8	263	264	62.88	0.26	215	826.9	0.22	180	818.2	0.18	155	861.1	0.26	252	969.2	868.9	80.2	9.2%	54,634		
	2	1	16	7	262	287	73.16	0.11	70	636.4	0.15	117	780.0	0.23	172	747.8	0.24	181	754.2	729.6	73.5	10.1%	53,377		
	2	1	17	8	258	266	61.53	0.25	197	788.0	0.18	115	638.9	0.21	155	738.1	0.15	111	740.0	726.2	72.3	10.0%	44,686		
	2	1	19	10	272	300	59.60	0.26	232	892.3	0.24	190	791.7	0.21	163	776.2	0.20	166	830.0	822.5	59.7	7.3%	49,023		
	2	1	20	10	260	271	74.79	0.18	134	744.4	0.12	81	675.0	0.23	149	647.8	0.22	142	645.5	678.2	53.3	7.9%	50,721		
	2	2	1	6	234	167	38.02	0.16	124	775.0	0.22	152	690.9	0.24	190	791.7	0.21	160	761.9	754.9	51.2	6.8%	28,700		
	2	2	5	8	264	287	72.58	0.19	124	652.6	0.23	167	726.1	0.17	124	729.4	0.21	133	633.3	685.4	57.3	8.4%	49,744		
	2	2	8	8	251	272	50.90	0.26	145	557.7	0.29	167	575.9	0.23	139	158.0	0.23	142	617.4	477.2	247.4	51.8%	24,291		
	2	2	10	8	247	256	65.80	0.21	137	652.4	0.21	144	685.7	0.21	158	165.0	0.29	221	762.1	566.3	313.4	55.3%	37,262		
	2	2	13	11	267	293	64.22	0.23	152	660.9	0.10	76	760.0	0.20	165	173.0	0.26	190	730.8	581.2	317.9	54.7%	37,322		
	2	2	15	8	261	273	70.92	0.28	188	671.4	0.21	151	719.0	0.21	133	186.0	0.31	215	693.5	567.5	294.5	51.9%	40,248		
	2	2	16	8	257	277	64.42	0.24	164	683.3	0.26	168	646.2	0.31	186	114.0	0.23	157	682.6	531.5	322.0	60.6%	34,241		
2	2	17	8	263	298	67.98	0.18	128	711.1	0.20	139	695.0	0.17	114	184.0	0.17	114	670.6	565.2	294.1	52.0%	38,421			
2	2	18	6	225	151	26.82	0.26	170	653.8	0.24	146	608.3	0.25	184	168.0	0.28	189	675.0	526.3	277.7	52.8%	14,115			
2	2	19	12	266	315	71.09	0.27	159	588.9	0.27	169	625.9	0.28	168	154.0	0.25	141	564.0	483.2	255.1	52.8%	34,351			
2	3	3	8	248	258	63.02	0.34	227	667.6	0.19	123	647.4	0.21	154	201.0	0.28	167	596.4	528.1	254.2	48.1%	33,282			
2	3	4	8	256	255	63.40	0.28	194	692.9	0.19	150	789.5	0.29	201	129.0	0.31	211	680.6	573.0	346.4	60.5%	36,328			
2	3	7	12	283	379	106.95	0.19	123	647.4	0.28	193	689.3	0.26	181	696.2	0.23	156	678.3	677.8	24.9	3.7%	72,487			
2	3	8	6	251	236	55.95	0.12	79	658.3	0.15	92	613.3	0.20	125	625.0	0.15	98	653.3	637.5	25.2	3.9%	35,668			
2	3	10	8	261	289	63.82	0.18	125	694.4	0.17	114	670.6	0.19	130	684.2	0.25	174	696.0	686.3	13.5	2.0%	43,800			
2	3	13	7	228	186	36.77	0.25	180	720.0	0.31	206	664.5	0.31	200	645.2	0.24	174	725.0	688.7	46.1	6.7%	25,322			
2	3	17	7	231	201	58.61	0.28	152	542.9	0.25	117	468.0	0.25	141	564.0	0.28	196	700.0	568.7	111.7	19.6%	33,332			
2	3	18	8	257	258	51.55	0.20	136	680.0	0.27	182	674.1	0.21	151	719.0	0.25	170	680.0	688.3	23.9	3.5%	35,481			
2	3	19	8	265	290	62.37	0.31	192	619.4	0.20	120	600.0	0.27	177	655.6	0.24	165	687.5	640.6	44.8	7.0%	39,954			
2	4	1	7	245	213	43.69	0.31	230	741.9	0.21	165	785.7	0.25	218	872.0	0.21	164	781.0	795.2	63.3	8.0%	34,740			
3	1	11	5	210	121	25.79	0.56	485	866.1	0.47	392	834.0	0.60	479	798.3	0.30	248	826.7	831.3	32.1	3.9%	21,439			
3	2	1	7	254	216	52.27	0.12	86	716.7	0.24	154	641.7	0.15	99	660.0	0.16	110	687.5	676.5	37.8	5.6%	35,358			

Sample	AWL		Fish			Skein		Subsamples																Mean Egg/g	SD	CV	Estimated Eggs/Female
	Card	#	Age	Len	Wt	Weight (Thawed)	Wt	1				2				3				4							
								Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g						
18	3	2	13	5	248	209	48.55	0.53	347	654.7	0.37	252	681.1	0.42	305	726.2	0.54	396	733.3	698.8	43.2	6.2%	33,928				
	3	2	17	4	218	143	23.49	0.17	144	847.1	0.13	112	861.5	0.10	96	960.0	0.21	161	766.7	858.8	91.6	10.7%	20,174				
	3	3	3	4	222	138	28.20	0.24	160	666.7	0.12	82	683.3	0.15	111	740.0	0.20	134	670.0	690.0	39.4	5.7%	19,458				
	3	3	12	9	270	261	48.05	0.39	249	638.5	0.40	236	590.0	0.57	315	552.6	0.58	334	575.9	589.2	41.9	7.1%	28,313				
	3	4	6	4	214	139	29.57	0.26	178	684.6	0.29	192	662.1	0.31	206	664.5	0.23	147	639.1	662.6	21.5	3.2%	19,593				
	3	5	18	3	189	81	15.79	0.21	183	871.4	0.13	108	830.8	0.10	94	940.0	0.19	166	873.7	879.0	52.2	5.9%	13,879				
	3	6	6	5	225	174	42.85	0.15	110	733.3	0.18	127	705.6	0.18	129	716.7	0.14	103	735.7	722.8	16.5	2.3%	30,973				
	3	6	7	4	217	131	21.89	0.28	220	785.7	0.24	176	733.3	0.15	122	813.3	0.16	130	812.5	786.2	43.3	5.5%	17,210				
	3	6	9	3	197	91	18.44	0.12	94	783.3	0.23	205	891.3	0.15	120	800.0	0.14	129	921.4	849.0	78.2	9.2%	15,656				
	3	7	1	10	268	316	80.86	0.21	129	614.3	0.22	139	631.8	0.18	118	655.6	0.22	132	600.0	625.4	27.6	4.4%	50,571				
	3	7	15	5	217	131	20.90	0.12	90	750.0	0.14	89	635.7	0.13	95	730.8	0.18	134	744.4	715.2	61.9	8.7%	14,948				
	3	8	1	3	187	82	7.97	0.12	104	866.7	0.13	114	876.9	0.11	86	871.8	0.10	111	1110.0	908.9	162.5	17.9%	7,244				
	3	8	3	5	231	164	36.67	0.18	132	733.3	0.21	153	728.6	0.16	104	650.0	0.16	107	668.8	695.2	48.6	7.0%	25,492				
	3	8	4	3	185	77	10.40	0.10	68	680.0	0.15	117	780.0	0.13	115	884.6	0.12	94	783.3	782.0	96.5	12.3%	8,133				
	3	8	5	4	204	125	25.00	0.54	416	770.4	0.56	454	810.7	0.60	474	790.0	0.56	449	801.8	793.2	20.1	2.5%	19,830				
	3	8	11	9	265	279	81.89	0.55	310	563.6	0.47	273	580.9	0.38	221	581.6	0.42	219	521.4	561.9	32.6	5.8%	46,012				
	3	8	19	4	211	121	24.12	0.17	109	641.2	0.16	113	706.3	0.21	197	938.1	0.17	170	1000.0	821.4	201.4	24.5%	19,812				
	3	9	12	3	187	86	20.27	0.45	379	842.2	0.41	334	814.6	0.45	406	902.2	0.43	398	925.6	871.2	59.5	6.8%	17,659				
	3	9	20	10	251	264	66.62	0.16	105	656.3	0.28	211	753.6	0.18	137	761.1	0.30	210	700.0	717.7	56.8	7.9%	47,815				
	3	10	11	5	231	186	45.15	0.20	141	705.0	0.24	167	695.8	0.19	137	721.1	0.19	123	647.4	692.3	36.6	5.3%	31,258				
	3	10	15	9	264	313	87.78	0.21	159	757.1	0.13	108	830.8	0.21	137	652.4	0.12	78	650.0	722.6	101.3	14.0%	63,427				
	3	10	18	4	202	102	19.99	0.14	125	892.9	0.13	114	876.9	0.16	127	793.8	0.18	156	866.7	857.5	50.7	5.9%	17,142				
	3	10	20	5	233	193	44.02	0.32	213	665.6	0.35	239	682.9	0.37	264	713.5	0.56	387	691.1	688.3	23.0	3.3%	30,298				
	3	11	5	10	265	316	78.56	0.20	113	565.0	0.22	133	604.5	0.30	170	566.7	0.23	127	552.2	572.1	26.1	4.6%	44,944				
3	11	17	3	182	80	15.65	0.15	123	820.0	0.17	146	858.8	0.13	114	876.9	0.21	160	761.9	829.4	58.8	7.1%	12,980					
3	12	4	10	257	289	71.00	0.15	97	646.7	0.18	117	650.0	0.17	106	623.5	0.12	70	583.3	625.9	35.5	5.7%	44,438					
3	12	5	4	208	125	25.22	0.19	104	547.4	0.28	180	642.9	0.19	131	689.5	0.23	144	626.1	626.4	68.3	10.9%	15,799					
3	12	9	4	213	138	31.48	0.19	163	857.9	0.23	212	921.7	0.15	144	960.0	0.20	200	1000.0	934.9	69.8	7.5%	29,431					
3	12	15	4	204	110	20.67	0.17	139	817.6	0.14	113	807.1	0.13	99	761.5	0.15	126	840.0	840.0	38.1	4.5%	17,363					
3	13	2	4	197	88	15.08	0.18	130	722.2	0.20	149	745.0	0.12	94	783.3	0.15	115	766.7	765.0	23.5	3.1%	11,536					
3	13	3	13	253	243	51.14	0.51	335	656.9	0.40	291	727.5	0.24	194	808.3	0.30	193	643.3	709.0	87.5	12.3%	36,259					
3	13	18	3	179	75	13.90	0.14	118	842.9	0.13	115	884.6	0.13	91	700.0	0.11	87	790.9	804.6	91.9	11.4%	11,184					
3	13	19	3	184	85	8.93	0.18	155	861.1	0.26	224	861.5	0.16	150	937.5	0.12	105	875.0	883.8	42.0	4.8%	7,892					
3	14	7	3	187	79	15.95	0.11	109	990.9	0.14	86	614.3	0.11	91	827.3	0.16	86	537.5	742.5	237.9	32.0%	11,843					
3	14	14	4	220	124	26.55	0.15	117	780.0	0.16	109	681.3	0.19	126	663.2	0.20	138	690.0	703.6	60.2	8.6%	18,681					
3	14	15	4	211	111	17.40	0.25	278	1112.0	0.27	285	1055.6	0.16	198	1237.5	0.15	198	1320.0	1181.3	138.3	11.7%	20,554					
3	14	17	11	276	309	80.14	0.17	109	641.2	0.13	137	1053.8	0.15	103	686.7	0.15	175	1166.7	887.1	303.0	34.2%	71,091					
3	15	3	7	262	278	79.11	0.24	138	575.0	0.20	106	530.0	0.22	125	568.2	0.14	82	585.7	564.7	28.0	5.0%	44,675					
3	15	5	6	251	214	52.34	0.18	131	727.8	0.25	185	740.0	0.24	167	695.8	0.29	212	731.0	723.7	22.2	3.1%	37,876					
3	15	20	10	271	278	67.98	0.18	104	577.8	0.18	107	594.4	0.25	150	600.0	0.15	89	593.3	591.4	11.0	1.9%	40,203					
3	16	19	9	269	267	54.96	0.24	154	641.7	0.14	92	657.1	0.23	160	695.7	0.21	151	719.0	678.4	40.8	6.0%	37,284					
3	16	20	5	232	170	25.18	0.20	135	675.0	0.27	203	751.9	0.26	194	746.2	0.23	149	647.8	705.2	59.8	8.5%	17,757					
3	17	8	10	263	240	57.47	0.14	121	864.3	0.18	170	944.4	0.15	133	886.7	0.14	126	900.0	898.8	39.0	4.3%	51,657					
3	18	7	5	220	158	38.31	0.31	232	748.4	0.23	193	839.1	0.24	174	725.0	0.22	166	754.5	766.8	57.6	7.5%	29,375					

Appendix A. (page 4 of 4).

AWL			Fish			Skein Weight (Thawed)	Subsamples																Mean Egg/g	SD	CV	Estimated Eggs/Female
Sample	Card	#	Age	Len	Wt		1				2				3				4							
						Wt	Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g	Wt	Count	Egg/g						
3	19	6	5	231	156	34.50	0.21	146	695.2	0.20	127	635.0	0.18	126	700.0	0.18	110	611.1	660.3	51.0	7.7%	22,782				
3	19	15	5	249	198	34.33	0.21	128	609.5	0.29	173	596.6	0.23	139	604.3	0.23	137	595.7	601.5	7.6	1.3%	20,650				
3	20	2	10	266	272	64.24	0.19	121	636.8	0.19	130	684.2	0.19	133	700.0	0.21	152	723.8	686.2	42.4	6.2%	44,082				
3	20	12	11	264	265	55.64	0.25	151	604.0	0.13	72	553.8	0.22	123	559.1	0.16	94	587.5	576.1	27.4	4.8%	32,055				
3	20	17	12	279	333	77.50	0.25	173	692.0	0.24	157	654.2	0.31	227	732.3	0.23	153	665.2	685.9	40.1	5.8%	53,158				
3	21	6	5	241	187	44.62	0.64	419	654.7	0.64	385	601.6	0.43	227	527.9	0.62	382	616.1	600.1	61.3	10.2%	26,775				
3	21	9	12	285	334	86.12	0.26	145	557.7	0.25	155	620.0	0.26	172	661.5	0.25	136	544.0	595.8	63.4	10.6%	51,311				
3	22	2	5	240	175	38.22	0.28	184	657.1	0.26	168	646.2	0.26	170	653.8	0.18	114	633.3	647.6	12.2	1.9%	24,752				
4	7	3	11	270	327	87.38	0.21	150	714.3	0.22	187	850.0	0.19	145	763.2	0.24	173	720.8	762.1	72.2	9.5%	66,590				
4	7	4	11	264	343	102.95	0.60	377	628.3	0.49	318	649.0	0.37	232	627.0	0.57	340	596.5	625.2	25.0	4.0%	64,365				
4	10	5	13	264	289	62.81	0.16	112	700.0	0.29	203	700.0	0.21	142	676.2	0.20	134	670.0	686.5	18.2	2.6%	43,122				
4	10	20	11	250	281	55.25	0.22	166	754.5	0.21	141	671.4	0.24	181	754.2	0.23	156	678.3	714.6	53.1	7.4%	39,482				
20	1	8	11	276	353	99.08	0.15	92	613.3	0.16	112	700.0	0.24	155	645.8	0.19	122	642.1	650.3	41.8	6.4%	64,434				
21	2	10	13	285	408	115.02	0.29	178	613.8	0.27	178	659.3	0.18	117	650.0	0.19	123	647.4	642.6	22.9	3.6%	73,912				
2	2	14		270	325	59.08	0.16	130	812.5	0.22	174	790.9	0.21	173	133.0	0.25	197	788.0	631.1	383.6	60.8%	37,286				
2	3	5		245	218	40.14	0.24	161	670.8	0.24	150	625.0	0.20	129	645.0	0.24	178	741.7	670.6	58.8	8.8%	26,919				
19	2	10		245	250	76.03	0.20	144	720.0	0.23	155	673.9	0.30	199	663.3	0.21	140	666.7	681.0	30.5	4.5%	51,775				
18	1	11		266	337	85.34	0.27	170	629.6	0.14	82	585.7	0.18	115	638.9	0.24	145	604.2	614.6	28.0	4.5%	52,450				

Samples 12 and 20 were collected from Chenik and Iniskin on 27 April and 9 May, 1990, while samples 2 and 3 were collected from Iniskin and Chenik on 23 and 26 April, 1991.

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